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Abstract

Automatic control of the average core flux by measuring N^{16} coolant activity at the FRM Munich Research Reactor

by

M. Sommer,
Institut für Meß- und Regelungstechnik
und Laboratorium für Technische Physik
der Technischen Hochschule München

Stability of the neutron flux very often is a prerequisite for exact results of experiments using a reactor as a neutron source. Usually the flux is measured at the reflector of the core in order to control the total flux. As a result the flux at the chamber position is kept constant, but this leaves a possibility open for a variation of the average core flux by as much as 20 %, caused by a change of the flux distribution in and around the core.

To avoid this the average core flux of the FRM is kept constant by a new cascade control system using N^{16} coolant activity. The N^{16} activity depends on the fission rate in the core and exceeds all the rest of the activities of the coolant by far. It may be determined independent of small variations about the mean value of the water flow rate. A suitable arrangement will be described where the N^{16} activity depends only on the average core flux. The dependance is linear; the control signal, however, is delayed by about 10 sec with respect to the variations of the flux in the core. The gamma radiation of the N^{16} activity is determined

by measuring the current of an ionization chamber. The overall accuracy is 0.25 %. This current is averaged over a period of 8 sec. Its deviation from a demand current drives a fast auxiliary circuit. This fast circuit consists of a chamber near the core and a continuous regulating system operating the control rod. Fast variations of the neutron flux are levelled out by the auxiliary circuit, the average core flux is kept constant by the N^{16} circuit. The observation of thermal power as well as flux determinations for varying flux distribution in the core proved the stability of the desired average core flux even for long periods.

As a result of a constant average core flux the neutron beam intensity averaged over all beam tubes has a minimum of variations. A special arrangement and operation of the shim rods will be devised to still further decrease these variations. An optimal solution to this problem was theoretically found and proved by flux measurements in the core using an U^{235}-Thermopile.

The motion of the control rod should be limited to a small range about a fixed start position in order not to vary the flux distribution in the core appreciably. The control rod position is therefore tested every 15 sec. In case its positional change has already exceeded this limit, the shim rods are automatically moved in small steps until the control rod reaches its starting position again.

The discussed control circuits based at the N^{16} activity proved to be very successful, e.g. for intermittent reactor operation the variation of intensity of the P3 neutron beam always stayed below 1.8 % over a period of several weeks, for continuous operating at constant power of 1 MW the variation is lower as 0.7 % compared to former variations of 12 % at the same beam tube.